DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

WORKING PAPER

THE POLICY ANALYSIS MATRIX IN ZIMBABWE :

A METHODOLOGICAL INTRODUCTION

BY

WILLIAM A. MASTERS*

WORKING PAPER AEE 5/89

DEPARTMENT OF AGRICULTURAL ECONOMICS & EXTENSION
FACULTY OF AGRICULTURE, UNIVERSITY OF ZIMBABWE
P.O. BOX MP 167, MOUNT PLEASANT, HARARE
ZIMBABWE

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Summary

This paper discusses the methodology behind the policy analysis matrix (PAM), an approach to the study of incentives and incomes in alternative production activities. The PAM method uses average-cost budgets to list the costs and benefits of each activity, initially at market prices in terms of private income, and then at opportunity cost in terms of national income. The market-price budget shows the private profitability of the activity, while the opportunity-cost budget shows its contribution to the economy as a whole, indicating the degree of economic efficiency and comparative advantage enjoyed by the activity. Such data are needed for project appraisals, and for guiding public-sector investments towards more productive activities.

To complete the PAM, the opportunity-cost budget is subtracted from the budget at market prices, revealing a third budget of "divergences," or income transfers between that activity and others in the national economy. Such transfers could be caused by government policies, market failures, or both. In either case, they represent gains ("rents") or losses ("implicit taxes") which are not justified by the activity's contribution to national income. Transfers may be justified by other concerns, such as income distribution or food security, but all too often they serve no such purpose and actually conflict with government objectives. By revealing these hidden transfers, showing who gains and who loses from current policies and market structures, the PAM assists in the formulation of more appropriate future price policies and market regulations.

The matrix approach works by linking widely-available microeconomic, sectoral, and macroeconomic data in a simple, consistent framework, to provide static, partial-equilibrium indicators of the current situation. Such an approach is useful primarily where the historical or cross sectional data and complex modeling tools needed for more sophisticated approaches are unavailable. This paper reviews the strengths and weaknesses of the PAM method in the Zimbabwean context, and discusses how additional information about resource availabilities, elasticities of supply and demand, likely changes in technology or prices over time, differential risk factors, and the cross-price or general equilibrium effects of changing resource allocations could be used to extend the analysis, beyond the limitations of the indicator approach.

1. The PAM: A framework for the analysis of budget data

The policy analysis matrix (PAM)[1] consists of the following simple framework, with all entries in local currency per hectare:[2]

	OUTPUT REVENUE	TRADABLES COSTS	Domestic Resources CAPITAL COSTS	LABOUR COSTS	PROFIT
MARKET PRICES:	A	B	C	D	E (Private)
OPPORTUNITY COSTS:	F	G	H	I	J (National)
DIVERGENCES:	K	L	M	N	O (Transfer)

In each row, output revenue minus all costs equals profits, and in each column, private prices minus opportunity costs equals divergences. Although the interpretation of these terms requires some economic theory, the matrix is not in itself a theory, or a model of the economy. It is simply a set of definitions, or accounting identities.

In using the PAM approach, a researcher would build separate matrices for a variety of activities to be compared, generally because they are affected by some common policy, and/or compete for common resources. The PAMs could describe the same product

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[1]. The PAM as presented here was developed by Scott Pearson at the Food Research Institute, Stanford University. The general approach draws heavily on work presented in Scott Pearson, Dirk Stryker, and Charles Humphreys, Rice in West Africa: Policy and Economics (Stanford, CA: Stanford University Press, 1981), comparing rice production activities in several countries. The matrix formulation was developed later, and presented in Scott Pearson et. al., Portuguese Agriculture in Transition (Ithaca, NY: Cornell University Press, 1987), projecting the effects of Portugal's entry into the European Community. A general exposition of the approach will soon appear in Scott Pearson and Eric Monke, The Policy Analysis Matrix in Agricultural Development (Ithaca, NY: Cornell University Press, forthcoming). Some modifications of the methods presented in these sources have been made for this paper, but the underlying approach is the same.

[2]. A PAM could also be built in terms of local currency per tonne, in which case there would be a third column of domestic resources showing land rental costs. These are very difficult to estimate, however, especially in the Zimbabwean context. In the per-hectare version of the PAM used here, land is seen as a fixed factor which claims profits, jointly with the farmer's own management skill and willingness to bear risks. Thus the farmer's income is partly a return to his or her land and cannot be directly compared with a farmer's income elsewhere.

being produced in several places (as in a study of regional trade issues), and/or a variety of products being produced in one place (as in a study of national policy).

The results of a PAM-based study, both the matrices themselves and ratio indicators derived from the matrices, can serve two major roles in applied work. Firstly they provide opportunity-cost data for the economic analysis of projects and investment priorities, and secondly they show the incidence of macroeconomic, sectoral, and price policies and market failures, indicating how producers are affected by current conditions and providing insight into desirable future policies. In general economics research, the PAM brings together a wide range of economic tools in a single, simple framework, representing the state-of-the-art of measuring comparative advantage and income transfers.

1.1 The budget at market prices

The top row of the PAM is quite similar to an ordinary cost-of-production crop budget.[3] It consists of all revenue (entry A), minus all costs (entries B, C and D), equalling private profits (entry E). Revenue (A) may come from a single product, such as tea or tobacco, or it may come from several joint products, such as cotton seed and cotton lint. Costs are obviously very diverse, and all should be included. Anything omitted may bias the results. In particular, all labour (C) and capital costs (D) should be included, at their opportunity cost in market prices: their value in the highest-valued alternative activity from the farmer's point of view.

The market-price data in the first row of the PAM differ from ordinary cost-of-production budgets primarily in that they must be compiled in such a way as to make possible direct comparison with the opportunity-cost data in the second row. This is done in two ways. Firstly, PAM budgets must include processing and transport up to a point where the opportunity-cost value of each crop in consumption or trade can be measured. This means bringing the product to the gate of a major industrial or transport center, at which the item is ready for processing to meet domestic consumer demand, or for transport to meet foreign demand and supply. The processing requirements for most grains and oilseeds are minimal, since they are largely shipped in bulk, dry form. But for cotton in Zimbabwe, PAM budgets must include ginning, since it is lint and not raw seedcotton which is exported. On the transport side, the most convenient common

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3. The most complete published discussion of major issues in crop budgeting is Maxwell Brown, Farm Budgets: From Farm Income Analysis to Agricultural Project Analysis (Baltimore, MD: Johns Hopkins University Press, 1979).

location is generally a railhead depot near Harare or Bulawayo, at the centre of Zimbabwe's transport network.

Secondly, all costs must be broken down into their three macroeconomic categories: tradable goods, capital services, and labour.[4] The "tradable" category here should include anything which could enter into international trade, although it may not actually do so. Since these products could be traded, upper and lower limits on their opportunity costs are set by their import and export values in foreign currency. Capital services refers to the value of using assets for investment rather than for immediate consumption, and the opportunity costs of doing so are determined by the marginal value of capital in other available areas of investment. And finally, labour costs are defined conventionally as the services of all workers, whose opportunity cost is again their marginal productivity elsewhere in the economy. Capital and labour are the inherited wealth of the country; they are known as "domestic resources," or the domestic "factors" of production. In contrast, tradables are consumable products, representing current production; the net value of tradable outputs minus inputs is known as "value added."

Costs are grouped in this way because all items in each category are affected similarly by conditions in a single large national (or "macroeconomic") market, as well as by conditions in their own individual markets.[5] Thus the effects of current policies or

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4. These categories, and techniques for estimating the opportunity cost of the items in each category, were initially developed primarily for the cost-benefit analysis of projects. The pioneering approaches are the "Little-Mirrlees method", first published in Ian Little and James Mirrlees, Manual of Industrial Project Analysis in Developing Countries (Paris: OECD, 1969), revised and more widely distributed as Project Appraisal and Planning for Developing Countries (London: Heinemann, and New York: Basic Books, 1974); and the "UNIDO Guidelines," written by Partha Dasgupta, Stephen Marglin and Amartya Sen, and published as United Nations Industrial Development Organization, Guidelines for Project Evaluations (New York: United Nations, 1972). The PAM approach is therefore in part an effort to apply the lessons of twenty years' experience in project analysis to the analysis of policies in general.

5. A pioneering work emphasising the importance of the close relationship of microeconomic forces (in the markets governing food production, processing and consumption), with macroeconomic forces (governing the costs of foreign exchange, capital, and labour), is Peter Timmer, Walter Falcon and Scott Pearson, Food Policy Analysis (Baltimore, MD: Johns Hopkins University Press, 1983).

potential future changes in the markets for tradables and for domestic factors (capital and labour) can be examined quickly and easily in the context of the PAM. Costs which do not immediately fit into any of these three categories (all nontradable, nonfactor inputs such as transport and tractor services, electricity, or irrigation water), may be included in a separate column during the process of compiling the PAM, but should eventually be broken down into their three macroeconomic components if the impact of macroeconomic conditions on each activbity is to be seen clearly.[6] In the context of the PAM, domestic factors (capital and labour) are the only budget items which are completely and permanently nontradable; they are also known as domestic resources.

The market-prices budget shows the private profitability of each enterprise. Firstly, private profitability is the farmer's incentive to grow the crop -- and to the extent that the budgets successfully approximate marginal costs and returns (and this is usually the case in agriculture), PAM profits are also the incentive for each farmer to expand or reduce production of the crop with an additional hectare. When crop profits are higher than farmers' alternatives, we can expect farmers to switch to that crop as quickly as they can bring resources in from elsewhere. Conversely, when profits are relatively low, we can expect farmers to cut back as soon as they can shift resources to other uses. And if PAMs are constructed for all the major crops grown in a given farming system, they can be combined in proportion to the cropping pattern to yield a whole-farm PAM. This now gives total profits on the whole operation, which allows additional insight into the economic forces at work on that type of farm. If whole-farm profits are low, people will try to leave that farming system entirely, seeking work elsewhere.

Secondly, in absolute terms, profitability is the farmer's income from the crop, out of which funds are saved and re-invested. A crop with low profitability, while it may still be undertaken if the farmer's alternatives are even worse, will yield little surplus for investment in that or other activities. And if whole-farm profits are low, the farmer will be unable to improve his or her fields by buying fertilizer, fencing, or better ploughing animals and equipment, as well as be unwilling to

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6. One alternative to breaking down nontradable, nonfactor budget items in the budget is to make a conversion factor for each one. This is the approach typically used by the World Bank in its project appraisals, because it allows them to do the breakdown and application of macroeconomic opportunity costs only once for each item, and then to use the same conversion factors again and again. A big disadvantage of this approach, however, is that it hides that calculation from the ultimate user of the analysis.

invest family labour in spreading manure or building erosion controls such as drainage ditches and contour ridges. Soil productivity will therefore deteriorate, and the farm will yield less and less every year as the farmer uses up real resources accumulated in the past. This poverty trap is a common feature of farming everywhere in the world, although better-designed agricultural policies could do much to help farmers escape it.

In addition to farmer incomes, PAM budgets show the annual use of tradable inputs, capital and labour in each crop and for the whole farm. This reveals the demand for inputs and credit in each cropping system, indicating how input marketing and loan policies can assist farmers to undertake more profitable activities. With labour requirements, the budgets measure the demand for workers in the various farming systems, indicating how policies can help expand employment.

1.2 The budget at national opportunity cost

The second row of the PAM consists of the same items as the top row, in the same physical proportions, but the market price of each item is replaced by its national opportunity cost. This is defined as the item's value in its highest-valued alternative use, in any activity in the country that could feasibly be reached.[7] Thus national opportunity costs differ from market prices only in terms of perspective: market prices are really opportunity costs from the point of view of individual producers, while national opportunity costs are measured from the point of view of the nation as a whole. At national opportunity cost, the budget shows net national profits,[8] or the incremental

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[7]. Opportunity costs in this sense are very different from free-market equilibrium values, as emphasized in T.N. Srinivasan and Jagdish Bhagwati, "Shadow Prices for Project Selection in the Presence of Distortions: Effective Rates of Protection and Domestic Resource Costs," Journal of Political Economy, vol. 86, no. 1 (1978): 97-114. Free-market equilibrium values would exist if policies were changed; opportunity costs exist right now, measuring the real resource cost of a current activity.

[8]. National profits are often also called "social" profits. However, use of this term should not allow confusion with the Squire-van der Tak method of cost-benefit analysis, in which distributive weights are applied to opportunity costs according to an explicit social welfare function. This approach was pioneered by Lyn Squire and Herman van der Tak in their Economic Analysis of Projects (Baltimore, MD: Johns Hopkins University Press, 1975), but as the authors state in their preface to the sixth printing (1988), social weights are not widely used today. Policy-makers and analysts worldwide generally prefer to apply social weights after the cost-benefit analysis, rather than during it. This allows the initial analysis to show the flow of

contribution of the activity to national income.[9] This is simply what the activity produces for the economy as a whole (entry F), minus what it costs for the economy as a whole (G, H and I), to equal the net addition to the economy as a whole (J).

Opportunity costs in their strictest definition are constrained ("second-best") equilibrium values, corresponding to the prices at which national income and welfare would be maximized under current conditions. Strictly speaking, therefore, opportunity costs depend on the full set of supply and demand relations between all goods, since the value of each depends on the quantity supplied and demanded of it and of all other goods.

Unfortunately, there is usually far from enough data to make a complete model of supply and demand relationships -- even if there were general agreement on what such a model should look like. But it is precisely because data are scarce and modeling is difficult that the PAM approach is useful. In the PAM, relatively easily-obtained data are combined in simple average-cost budgets. This is known as the "indicator" approach, since it relies on single-number estimates to indicate current opportunity costs, rather than a fully-specified model of the economy.[10]

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real income, which can then be re-directed in line with government policy.

9. An activity's net contribution to national income is not the same as its share of national income. Very unprofitable activities could easily account for a large proportion of income, but they would consume more than they produce and therefore draw down the country's net resources every year.

10. There are three general alternatives to the indicator approach, all of which add the dimension of a theoretical model designed to predict behaviour under alternative circumstances. And while all of these modeling approaches have very important uses, their specifications and data requirements imply that, in many situations, they cannot reliably be used.

Firstly, individual commodity markets can be simulated, in models using full supply and demand curves (or elasticities for small changes around the current point) to find the equilibrium under alternative conditions. This single-market equilibrium approach, described in many textbooks, is a staple of policy analysis wherever the time-series and cross-sectional data needed to estimate supply and demand curves are available.

Secondly, "multi-market" simulation models can be built for a set of inter-related product and input markets, using either demand and supply elasticities for each item, as in Avishay Braverman, Jeffrey Hammer, and Anne Gron, "Multi-Market Analysis

There are clearly many limitations to the indicator approach, as detailed elsewhere in this paper. But well-formulated indicators do reveal important information, and can make maximum use of what limited data are available, with a minimum of bias from the specifications of a model. The PAM's structure enhances the value of opportunity-cost indicators by making the calculations behind them as simple and explicit as possible. This helps the analyst to provide substantially better information for economic analysis than could either be directly observed from market prices, or be derived from complex theoretical models.[11] How the indicator approach works is briefly outlined here, and discussed in more detail in section 3 of this paper.

For tradable inputs and products, national opportunity cost is bounded by the item's values in trade. To estimate these bounds, we take current prices in the foreign market with which we would trade, add (for importing) or subtract (for exporting) transport and processing costs, and multiply this foreign-currency "border price" by an estimate of the opportunity cost of foreign exchange. The opportunity cost of foreign exchange is most easily seen as the value of what foreign exchange can buy (tradable goods, either importable or exportable), in terms of what it can't buy (nontradables, largely labour and other domestic resources). This is known as the Real Exchange Rate (RER), measured by an index of the domestic currency prices for a

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of Agricultural Price Policies in an Operational Context: The Case of Cyprus," World Bank Economic Review, vol. 1, no. 2 (1987): 337-56; or behavioural equations (profit and utility functions) for each group of producers and consumers, as in Inderjit Singh, Lyn Squire and James Kirchner, "Agricultural Pricing and Marketing Policies in and African Context: A Framework for Analysis," World Bank Staff Working Paper No. 743 (Washington, DC: The World Bank, 1985).

Thirdly, mathematical programming or optimization models can be built for a set of inter-related activities, specifying available technologies, resource constraints, and relative preferences, and replicating the economy by showing the mix of activities which would maximize producers' income and/or consumers' welfare, under a variety of conditions. A wide range of such models are discussed in Peter Hazell and Roger Norton, Mathematical Programming for Economic Analysis in Agriculture (New York, NY: Macmillan).

11. An early paper noting this issue in the context of limited data availability was Hollis Chenery, "Comparative Advantage and Development Policy," American Economic Review vol. 51, no. 1 (1961), pp. 18-51.

basket of tradable goods, over the domestic currency prices of a basket of nontradables.[12]

Tradable goods whose domestic opportunity-cost value currently lies within these bounds (usually perishable or bulky low-value items, such as mhunga or vegetables) are temporarily nontradable. For these, we must take current market prices and subtract (or add) any observed taxes (or subsidies), plus any measurable effects of rationing and/or market failures.

For the opportunity cost of labour, we want the highest income each type of worker could receive in another job. For most unskilled Zimbabweans, the alternative to their current work is to go home (to their musha) and share in the work and scanty rewards of communal area farming. Thus the opportunity cost of unskilled labour is roughly the average return to agricultural labour in communal areas. Ideally, an estimate of the marginal returns to communal labour would be used, but estimates of this are highly error-prone.

For capital, we again would like an estimate of the marginal returns, but again will have to settle for an estimate of average returns. In fact, the estimation of returns to capital in Zimbabwe is so poor that standard figures used elsewhere will probably have to be substituted.

Obviously, such estimates of opportunity cost have a number of strong limitations. These will be addressed briefly here, and at greater length in section 5 of this paper. Firstly, they are subject to considerable measurement and specification error. Thus, a certain amount of sensitivity analysis should be applied to the completed matrices, to judge the reliability of all results. In addition, if the statistical variance of important variables is available, this can be used to perform tests of statistical significance on the results.[13]

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12. If an index of the prices of nontradable goods is not available, wage rates alone can be used instead, since the value of nontradables is mostly labour costs. This is likely to be less accurate, however, because measured wages rates may not reflect the economy-wide returns to labour very well, and will certainly not include the returns to other domestic factors. Details on the RER approach are given in Sebastian Edwards, Exchange Rate Misalignment in Developing Countries (Baltimore, MD: Johns Hopkins University Press, 1988), and in numerous recent textbooks.

13. The importance of doing so is made clear by John McIntire and Chris Delgado, in "Statistical Significance of Indicators of Efficiency and Incentives: Examples from West African Agriculture," American Journal of Agricultural Economics,

Secondly, all estimates are made at current levels of production and consumption of each item. Such an approach is of limited value in predicting the effects of changing conditions, for which models of economic behaviour such as elasticity estimates (or whole supply and demand equations) are needed. PAMs can be combined to form rough step-wise supply curves, but this is not their primary purpose. Therefore, to consider the effects of significant changes in policy or supply and demand conditions, users of the PAM should consider any available evidence on what producers' and consumers' responses are likely to be.

Thirdly, opportunity costs in the PAM are "partial equilibrium" prices, which do not include the feed-back effects of changing one price (or quantity) on the supply and demand schedules and opportunity costs of other goods. In reality, of course, there are such "general equilibrium" effects, although they tend to be smaller and slower to occur than the direct partial equilibrium effect of the change. Complete studies of major changes in resource allocation should include some reference to these effects, if only to suggest an area of concern.

When using such a partial equilibrium indicator approach, opportunity costs are the value of each item in alternative uses right now, for marginal changes. All government policies and other "structural" features of the economy are taken as given.[14] Thus profits at opportunity costs are each activity's net contribution to national income at the present moment, independently of any changes in policy. Opportunity costs measured in this way will remain valid for reasonably small changes in policy or other conditions, but as noted elsewhere in this paper, other information would be needed if the effects of major changes in policy are to be fully understood.

In general, compiling data for the second row of the PAM is the most difficult part of using the PAM approach, since it requires making a realistic assessment of what the value of each item in its next-best alternative use really is. This is, by definition, estimating something which is not observable, so it requires considerable sensitivity to the particuliarities of the situation

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Nov. 1985: 733-38.

[14]. The term "structural" generally refers to non-price issues in the economy. This could include anything from physical infrastructure, to political constraints on the government and the pattern of land ownership. The importance of non-price factors is emphasized in, for example, Chris Delgado and John Mellor, "A Structural View of Policy Issues in African Agricultural Development," American Journal of Agricultural Economics, vol. 66 (1984): 665-70.

-- but this would be much the same for the application of any other method of economic analysis.

1.3 Divergences (the difference between the two budgets)

The third row of the PAM is simply the first row minus the second, giving the divergences between market prices and opportunity costs.[15] These divergences may be small differences in prices, but when multiplied by the quantities involved they produce quite large total amounts of money.

Most of this money is simply transfered within the economy, to or from the government, individuals, and private companies. Thus, the third row of the PAM is also known as the "transfer" row. Revenue items with positive third-row entries (where market prices are above opportunity costs) are being implicitly subsidized; cost items with positive entries are being implicitly taxed. For the activity as a whole, the budget reveals transfer profits, or the net effect on profitability of all transfers combined. Activities with positive transfer profits are being subsidized, those with negative transfer profits are being taxed.

Most of these "taxes" and "subsidies" never pass through the government's hands; they are transfered directly to and from farmers, input and services suppliers, and processing and transport firms. As such they are generally known as "rents" or "excess profits," earned not through the activity's marginal contribution to national income, but through privileged access to some right or resource. While some government subsidies are effectively targeted to the poor, many transfers are received by those who are already rich and/or powerful -- those who have access to the rights and resources able to capture excess profits. Furthermore, someone must pay the transfers: this is often the poor and/or weak, who have no privileged rights and are forced to undertake marginal activities not favoured by others.

In addition to the income distribution effects of tansfers, they have affect total national income as well. People will try to avoid activities which pay negative transfers, seeking out those which receive positive ones. To the extent that people can do so, the total value of national production falls, and negative transfers become larger than the positive ones. This is known in welfare economics as the dead-weight loss caused by the

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[15]. Much of the terminology used here is due to Max Corden, in his Trade Policy and Economic Welfare (Oxford: Clarendon Press, 1974), building on the extensive literature of welfare economics.

transfer.[16] Such dead-weight losses are typically relatively small in the short-run, as long as people cannot shift their activities to avoid (or chase after) transfer profits. But over time, the lost national income becomes larger and larger, as people expend more and more resources seeking out excess profits, abandoning more productive activities.[17]

1.3.1 Policy-induced divergences. Many divergences, whether or not they involve government expenditure or revenue, are a direct effect of government policy. These could be policies designed explicitly to alter market prices, such as minimum wages or price controls; or to ration out a scarce item, such as wheat or imported equipment spares; or to raise and spend government revenue, such as taxes and subsidies. In most countries, agricultural goods are affected by some combination of all three types of policy, which create divergences by changing the prices people pay without significantly affecting national opportunity costs.

Opportunity costs are difficult to change because they cannot be observed directly; they are the hidden results of long-term interactions of fundamental forces in the economy. Those fundamental forces are the nation's resources (inherited capital, including buildings and machinery as well as natural and human resources) and available technology (the ways in which those resources can be used to produce goods and services), determining the supply of various goods; the nation's income (which it earns using its resources and technology) and preferences (what the nation is willing to pay for various items), determining demand for those goods; and the structure and infrastructure of markets, determining marketing costs and the extent of market failures in the matching of supply with demand.

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16. The dead-weight loss occurs because people in the economy see only market prices, rather than opportunity costs, and therefore fail to produce the highest possible national income. The difference between the national income which would occur if there were no divergences, and the national income which is produced given existing divergences, is the dead-weight loss. (In general welfare economics, dead-weight loss also includes the change in consumer surplus, but this is not necessarily measured in the simple PAM approach.)

17. In such situations, people will actually spend resources to create and capture positive transfers which did not exist before. A seminal article pointing out the importance of transfers in the development process is Anne Krueger, "The Political Economy of the Rent-Seeking Society," American Economic Review, vol. 64 (1974): 291-303.

Only policies which modify these fundamental economic forces can change national opportunity costs. For example, a policy to undertake crop-improvement research could easily improve technology and thereby lower the opportunity cost of a crop, as long as the total value of the improvements is greater than the cost of research. But a policy to subsidize that crop so that farmers can grow more of it with their current technology, would have to improve crop marketing by offsetting a market failure in order to do anything other than transfer income from consumers (and/or taxpayers) to farmers, with a net reduction in national income.

Most policies, even if they are directed at altering the country's economic fundamentals, cause divergences, and thereby create a transfer to or from the buyers and sellers of a good. In the case of a minimum wage, for example, the transfer is received by those employees who actually receive that wage, and it is paid jointly by their employers, by consumers who buy their products (who must pay more for the workers' work), and by unemployed and informal-sector workers (who would be able to get a formal-sector job, albeit at a lower wage, if employers could pay each person less and therefore hire more people). Most economists would agree that some such transfer can almost always help expand the economy, by offsetting the market power of employers (who are few) against their employees (who are many). In the case of scarce rationed items such as equipment spares, the transfer goes to those who do receive the allocation, and is paid by those who buy anything produced with the rationed items.

One major objective of PAM research is to show the incidence of such transfers (that is, who pays and who receives how much of them), so that policy-makers can decide how much transfer is actually desired. If all policy-induced transfers were deliberate policy choices, then discovering them would not be very interesting. But most policy-induced transfers are not explicit goals of policy, and may even be unanticipated side-effects of which government officials and others remain unaware. The PAM is designed to uncover and measure such hidden, often unintentional, transfer effects of policy, so that they can be brought more closely into line with the objectives of government.

1.3.2 The effects of market failures. Although many divergences are caused by active undertakings of the government, others arise independently of government, within the private sector. These are the results of market failures, which can and do cause significant divergences as long they remain uncorrected by government. There are three main types of market failures: the exercise of market power (as monopolies or monopsonies), and the presence of externalities (either positive or negative), and incomplete information.

Market power can be exercised whenever a potential buyer is unable to find another seller (so that the seller enjoys monopoly power), or vice versa (so that the buyer has monopsony power). For example, a rural shop-owner who is the only person with cash at the start of the marketing season may have some monopsony power over farmers who want to sell their crops early, and will therefore be able to pay farmers low prices (e.g. the grade C price for grade A grain), or to force them to buy goods at inflated prices in his shop. Similarly, a transporter who is the only one operating in some remote area may be able to charge more than his opportunity costs, and still know that no one else will offer to transport peoples' grain more cheaply. Such situations commonly cause substantial transfers between farmers and rural shop-owners, transporters, and others.

A second major source of market failures is externalities in production or consumption. These are costs (or benefits) of a good which the buyer (or seller) doesn't have to pay (or doesn't receive). For example, some pesticides may be cheap and effective for a single farmer to buy and use, but doing so might poison the water for his neighbour's cattle. Since the neighbors don't receive compensation for this, the national opportunity price of the pesticide should be its market price plus its cost to the neighbours. Similarly, buying fences for a grazing scheme might be quite expensive for a single farmer, but doing so will improve the pasture on the remaining unfenced common lands and therefore help other farmers. But since the other farmers don't pay for these benefits, the national opportunity cost of the fencing should be its market price minus its benefits to the other farmers.

Finally, incomplete information is a cause of market failures when it leads people to trade more or less than they would if they knew more about the item being traded. For example, farmers may buy too little insecticide simply because they don't know how to use it, and processing firms may buy too little tea or coffee when they cannot control its quality. Like the exercise of market power and the influence of externalities, incomplete information is indeed a major problem, especially in remote rural areas.

Unfortunately, fixing market failures is expensive. It requires expenditures to provide better infrastructure, alternative buyers or sellers, and/or regulation and police protection against the exercise of market power. For example, in the case of monopoly transporters, a researcher may estimate that the marginal cost of rural transport is only $1,00 per bag for a 50 km run on secondary dust roads, and yet find that many transporters charge $1,50. This might represent a transfer of over a million dollars each year from farmers to transporters.

To allow farmers to pay only $1,00, the government would have to spend a substantial amount to build better roads, subsidize government transport with lorries from the army or the District Development Fund, and/or to post policemen at hundreds of roadblocks around the country. These interventions might cost an additional, say, $0,40 -- so that the true opportunity cost of rural transport would be $1,40, not the $1,00 initially observed. It would simply not be possible to provide transport services at only $1,00 per bag, even though this may well be its true marginal cost to an individual monopoly lorry owner.

In general, improvements in national income from correcting market failures are realized only up to the point where the marginal benefits from the intervention equal its marginal costs. This is much less than the original transfer, although it may still be extremely significant. In the PAM, such net benefits (where they could be estimated) could be separated out from other divergences, as a fourth row of "uncorrected market failures," while the "effects of policy" row would include only the effects of existing policies. Of course, both "uncorrected market failures" and "effects of policy" are policy issues: uncorrected market failures are the costs of interventions the government doesn't do but should, and effects of policy are the costs of interventions the government does do but shouldn't. The two rows differ only in the origin of the divergence.

In this simplest version of the PAM, the two kinds of divergence are combined into the third row, which covers both the effects of policy and of uncorrected market failures. Doing so should not be taken to suggest that market failures are an insignificant issue, or that all divergences are the effects of policy. In fact, as long as it is opportunity cost (the second row of the PAM) which is being measured, it is impossible to tell whether any divergences thus revealed (in the third row) are the effects of policy or of market failures. Divergences are taken to be the effects of observable taxes and subsidies alone only in the case of temporary nontradables, where the third row must be estimated directly. This is done only because it is almost impossible to measure market failures, which is a problem common to all economic methods.

In any event, for the initial uses of the PAM in analysing comparative advantage, whether a divergence is due to a direct policy intervention or to an uncorrected market failure is of limited practical importance. What matters is that a transfer is occuring within the economy, so that market prices are different from national opportunity costs, and private profits are different from national profits. This allows the initial assessment of comparative advantage and economic efficiency, quite independently of whether it is government or private action which causes the transfer. It is only later, in the design of commodity and sectoral policies to help expand socially

profitable activities and/or shrink unprofitable ones that the precise cause of the divergence matters -- and this is a task beyond the initial diagnostic role of the PAM approach.

1.4 Interpreting the PAM

The data and estimates in a PAM can be interpreted directly, as measures of revenues, costs, profits and transfers in a particular activity, in Zimbabwe dollars per hectare. But the PAM approach is most powerful in that it allows comparison of different activities, using all the unit-less ratio indicators of comparative advantage and policy intervention which have been developed over the past several decades.

For measuring comparative advantage, the PAM shows the domestic resource cost (DRC) of the activity. This is defined as the opportunity-cost value of domestic factors used in the activity, divided by the opportunity cost of the value added (output minus tradable inputs) produced by the activity. Put more simply, a DRC is the value of domestic resources needed to produce a dollar's worth of tradable goods in a given activity.[18] In the PAM as shown on page 1, this is [(H+I)/(F-G)]. The lower the DRC, the more comparative advantage is enjoyed by that enterprise; and as long as the DRC is below one, the activity is a net contributor to national income. Note that the DRC contains the same information as social profits from the PAM (J = F-G-H-I), but is expressed as a ratio instead of a sum so that the units cancel out.

A DRC, however, includes information only from the second row of the PAM, and says nothing about the private profitability and the impact of transfers on incomes and incentives. Measures of this are also included in the PAM, including the nominal protection coefficient (NPC), measuring the proportion of gross revenue which is derived from government policy and other transfers [A/F) - 1]; the effective protection coefficient (EPC), measuring the proportion of net value added derived from transfers [([A-B]/[F-G]) - 1]; and the producer subsidy equivalent (PSE) of government policy, measuring the proportion of gross revenue which would equal the total transfers received [(D/A) - 1].[19]

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18. The domestic resource cost indicator was independently developed by Anne Krueger in the U.S. and Michael Bruno in Israel. It first entered the general professional literature with Anne Krueger, "Some Economic Costs of Exchange Control: The Turkish Case" Journal of Polictical Economy, vol.'74, no. 5 (1966): 466-80.

19. The concepts of nominal protection, effective protection, and domestic resource costs are compared and discussed in a number of articles, most notably in a special issue of the Journal of Political Economy, vol. 80, no. 1 (1972).

All of these measures, and others which are less widely used, can easily be drawn out of the PAM for use in the design of projects and policies affecting the activities described by the PAM. Since they are standard indicators used in many other studies, they can easily be compared with the results of previous work. This makes the PAM an extremely flexible technique, useful in a wide variety of contexts. In addition, the PAM approach produces research results which are unusually explicit in terms of the assumptions and data utilized. This allows other researchers to pick up an old PAM study and update it or modify it for their own use, with a minimum of difficulty -- which makes the PAM a particularly useful research tool for on-going policy analysis within governments.

The articles by Michael Bruno, "Domestic Resource Costs and Effective Protection: Clarification and Synthesis," pages 16-33 and by Anne Krueger, "Evaluating Restrictionist Trade Regimes: Theory and Measurement," pages 48-62 are particularly important. See also later articles by Scott Pearson, "Net Social Profitability, Domestic Resource Costs and Effective Rate of Protection," Journal of Development Studies, vol. 12, no. 4 (1976): 321-33; and T.N. Srinivasan and Jagdish Bhagwati, "Shadow Prices for Project Selection in the Presence of Distortions: Effective Rates of Protection and Domestic Resource Costs," Journal of Political Economy, vol. 86, no. 1 (1978): 97-114. A more empirically-oriented survey of their application is Pasquale Scandizzo and Colin Bruce, "Methodologies for Measuring Agricultural Price Intervention Effects," World Bank Staff Working Paper No. 394 (Washington, DC: The World Bank, 1980).

An example of their application in Southern Africa is the Ph. D. dissertation of Doris Jansen, Agricultural Policy and Performance in Zambia: History, Prospects, and Proposals for Change (Berkeley, CA: University of California Institute of International Studies, 1977). In Zimbabwe, the pioneering empirical work is by Aidan O'Driscoll and Tobias Takavarasha, "Crop Price Policy Analysis" (Harare: University of Zimbabwe, Department of Agricultural Economics and Extension, 1988).

2. The scope and limits of the PAM approach

2.1 Is the PAM the right tool for the job?

The first task of any research project is to choose methods which will be appropriate for answering the questions in hand. Some aspects of the PAM which help define its recommendation domain are summarized here; others will be apparent from the discussion elsewhere in this paper. Still other limitations are discussed in section 5, where extensions of the PAM for a variety of purposes are discussed.

Firstly, as was noted at the outset, the PAM consists of a matrix of accounting identities, which are always true simply by the definition of the terms involved. The PAM contains no behavioural models, which might predict what people would do under different conditions -- so that the PAM is not well suited to the analysis of producer response to different policies, prices, or resource scarcities. Making such behavioural predictions is the province of economic theory, and testing the empirical validity of those theories is the province of econometrics; these are the methods which would be needed to estimate behavioural functions in a model of the economy. Again, the PAM itself is best suited to diagnostic, not prescriptive work.

That being said, it is possible to use PAM budgets to build a model of the agricultural sector, for prescriptive purposes. This would be done by specifying the current and potential total area under each crop enterprise, along with the other resources available to it at the given prices and opportunity costs. These specifications would define the resource balances of a mathematical programming model, while the PAM budgets would define the technical coefficients. Such a model could then be solved repeatedly under alternative conditions, to simulate producer response.[20]

But even with such a model, information about the rate at which resources could move into or leave each activity over time (and where those resources would come from or go to), would have to be assessed separately. An alternative approach would be to take econometric estimates of short- and long-term elasticities, to

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[20]. One example of this type of model is given in the unpublished doctoral dissertation of Frederic Martin, "Food Security and Comparative Advantage in Senegal: A Micro-Macro Approach," (East Lansing, MI: Michigan State University Department of Agricultural Economics, 1988).

suggest how quickly producers in each farming system would respond to profitability changes.[21]

Secondly, the accounting identities in the PAM are average-cost budgets. This makes the PAM generally better suited to answering questions about agriculture than about industry. In agriculture, a given product will have many producers, each of whom works within a limited range of different techniques, with relatively constant returns to increased output over the short run. Thus, marginal costs and returns in the agricultural industry can reliably be approximated by a relatively small number of average-cost budgets. This would also be true of some industries, such as small-scale grain milling or light manufactures. But in heavier manufacturing and service industries each product is produced by a smaller number of more diverse firms, each of whom has average costs which may be very different from their marginal costs, so that representative average-cost budgets would be both difficult to compile, and not be very useful.[22]

Thirdly, the PAM is best suited to questions comparing various activities, rather than absolute questions about a particular activity. For example, although the PAM could be used to determine whether tea production in Zimbabwe is taxed or subsidized by government policy, the PAM would be better suited to a study comparing tea with coffee and other horticultural products in Zimbabwe, or comparing tea in Zimbabwe with tea in Kenya and elsewhere. One reason for this is that the researcher's analytical and measurement errors will have much more severe effects on the absolute results for a particular activity, than on the relative results when comparing different activities. For example, if the researcher forgets to include some cost category, then all profitabilities will be higher than

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21. A recent example of econometric work in Zimbabwe, showing how difficult obtaining reliable results can be, is in David Rohrbach's Ph.D. dissertation, "The Growth of Smallholder Maize Production in Zimbabwe: Causes and Implications for Food Security" (East Lansing, MI: Michigan State University, Department of Agricultural Economics, 1988). Elasticity estimates from a large number of econometric studies are given in Pasquale Scandizzo and Colin Bruce, "Methodologies for Estimating Agricultural Price Intervention Effects," World Bank Staff Working Paper No. 344 (Washington, DC: The World Bank).

22. This was shown for the Zimbabwean case by Doris Jansen, in her study on "Zimbabwe: Government Policy and the Manufacturing Sector" (Harare: Ministry of Industry and Energy Development, 1983). Her research shows clearly that, while it would be possible to build a PAM for each individual firm, problems of confidentiality and of the complexity of industrial budgets would make such an exercise very difficult indeed.

they should be -- but the differences in profitability between crops caused by this omission will be quite small. In general, the ranking of results from several matrices will be much more reliable than the results of any one matrix.

Another reason why the PAM approach is better suited to comparative work than for individual commodity studies is that much of the macroeconomic and other data in a PAM budget can be re-used in the budgets for different activities. For single commodity studies, investing in the creation of an entire PAM would be difficult to justify.

An additional consideration is that the PAM will generally be better suited to answering questions about comparative advantage in trade, rather than in production for the domestic market. This is because the PAM includes very little information about domestic demand, which is a major determinant of the opportunity-cost value of goods on the domestic market. Nevertheless, the PAM approach would be well suited to a comparison of traded products (such as cotton or maize) with non-traded ones (such as sorghum or millets), through their relative production costs and substitution possibilities in supply and demand.

Finally, a distinguishing feature of the PAM is its focus on the impact of divergences in macro prices. This has two principal implications. Firstly, if these macro divergences are small relative to divergences in particular markets, then the PAM is likely to be less useful than commodity studies which are addressed directly to single-market issues. And secondly, if the activities being compared have similar factor intensities, then those macro divergences will have little effect on relative profitabilities and the PAM will again not be very useful. For example, comparing various crops within the large-scale commercial sub-sector will do little to reveal the impact of macro pricing, since most crops have roughly similar intensities of tradable inputs, capital and labour. In contrast, comparing large-scale with small-scale production could yield dramatic results, since the latter use much less tradable inputs and capital, and much more labour, to produce the same products.

2.2 Selecting crop coverage

For comparative purposes, crops should be linked by some common resource, and yet be sufficiently different that they are affected differently by policy. To learn, for example, that banana production is more profitable than nyemba (cowpeas) would not be particularly interesting, because these products are almost entirely produced in very different areas, and are affected by few common policies. Similarly, it would not be very helpful to learn that nyemba and nyimo (cowpeas and bambara nuts) have similar profitabilities, since these products are produced in very similar systems, and are affected by policy in very similar ways.

Interesting comparisons could be quite narrowly defined, however, if resource use or the impact of policy differs significantly within a specific subsector. For example, the PAM approach would be well suited to the analysis of alternative cropping patterns under irrigation, or to the relative prices of different oilseeds, if these had distinct patterns of resource use. Nevertheless, before such a study were undertaken, it would probably be helpful to have in hand a broader study of the farm sector as a whole, putting each subsector into perspective.

In Zimbabwe, such a general study of comparative advantage should probably start with the major nationally-grown rainfed field crops: at least maize, cotton, groundnuts, and possibly sunflowers, plus the small grains (sorghum and millets) if one were particularly concerned with the semi-arid areas. These highly substitutable activities form the bulk of Zimbabwean agriculture, and profits in these activities generally define the lowest opportunity cost of farm labour and unirrigated land. The study from which this paper is drawn is limited to these half-dozen crops. However, the relationship between these crops and irrigated wheat/soyabeans and possibly tobacco would be important for a study focusing on large-scale commercial farming or irrigation policy, while their relationship with specialist crops such as sugar, rice, tea, coffee, and horticultural products would be relevant for a study of very large-scale and parastatal farming.

2.3 Selecting farming systems

Once crop coverage has been determined, the researcher must decide how many distinct budgets to produce for each crop. Obviously, the more budgets, the more accurate would be the study. Each farm is unique, and individual fields or plots within a farm vary significantly as well. But enumerating all of this would be a hopeless task, and quite unnecessary. In doing the analysis, the researcher is looking for insight and understanding into the impact of large-scale economic forces, not a complete census of everything. One therefore would like budgets which illustrate representative types of farms.

For a study which focuses on particular policies, the types of farms being represented should be defined in terms of their relationship to the policy being analysed. For example, to show the impact of trade policy, one would need to distinguish between farming systems according to what proportion of their products and inputs are tradable. Some additional insight might come from seeing how trade policy interacts with credit and other policies, so one might therefore also want to distinguish between farms which use more or less credit, labour, irrigation water, or other factors, but for the extra effort to be justified, significant links between these various secondary factors and the primary issue of trade policy would have to be shown.

In a general study of comparative advantage itself, we would have to take into account the impact of all national policies. Thus we would want to group farms into broad systems, each of which is characterized by a particular level and productivity of each type of input. Although in the real world there is, as mentioned above, an infinite range of budgets for each product, these tend to cluster around certain identifiable techniques. For example, in Zimbabwe any casual observer will notice two broad groups of techniques: one animal-powered, hand-weeded, low-fertilizer system, and one tractor-drawn, pesticide- and fertilizer-using system. This of course reflects the dual nature of Zimbabwean agriculture, with both very small and very large farms. This duality originated in a long and bloody history of discriminatory government, including the expropriation of land. It is sustained in part by the indivisibility of farm mechanization, whereby small farms are too small to use tractors and other "lumpy" investments profitably; and in part by different relative factor prices, whereby large-scale farmers have much easier access to capital and imported inputs and therefore can substitute these factors for labour more easily than small-scale farmers.

Thus, in Zimbabwe we would certainly need to include at least two budgets for each crop, to capture these differences. In addition, one would want to draw regional distinctions based on rainfall, and perhaps based on transport costs as well. For many crops, only four or five budgets would suffice to capture the most of the national variability in production costs, and would give a highly robust picture of national comparative advantage across systems with different levels of labour, capital, credit, and imported input use.

This is the scope and detail aimed for in the study from which this paper is drawn, and it captures the great bulk of differences amongst farms. Further detail would probably not give much more insight into national-level sources of comparative advantage and the impact of macroeconomic and sectoral policies. But with more ambitious research goals, and with a larger research budget, one could go into much greater depth on the impact of particular sub-sectoral policies. For example, land tenure policy could be studied with a survey comparing a few crops in selected communal, resettlement, small- and large-scale commercial areas. But as discussed earlier, a reliable understanding of the effects of changing any particular policy would require much more information than just the PAMs themselves.

2.4 Selecting farm-to-market systems

Once the farming systems have been identified, each must be matched with its marketing system, bringing the product to a national and possibly international market. The costs incurred

here must, of course, be added to the on-farm costs, broken down in the same way into the PAM framework.

To identify these costs and break them down into their PAM components, a separate survey of transporters and processors will almost certainly be needed. In the Zimbabwean case, transporters serving the small-farm subsector have a very different cost structure from those serving large-scale farms. Thus each subsector would have a different post-farm budget. Also, differences within the subsectors might be important enough to warrant some additional disaggregation. For example, one might want to make separate transport budgets for communal area farmers who go directly to their GMB depots, and those who use collection points. One might also want to separate out those who are, for example, within scotch-cart distance (about 10 kms) of their collection point, from those who are further away.

For a study focusing on transport policy, one would of course need much more data, including more detail on the various arrangements used and probably including the effects of transport costs on farming practices. But for a general study of national comparative advantange, it is probably reasonable to use constant physical farm budgets, and use two or three different transport budgets to see their effect on private profitability and comparative advantage for each system.

For some products, several distinct processing and marketing channels may exist, which could make for an interesting analysis of marketing policy if evaluated separately. For example, in Zimbabwe groundnuts from communal areas destined for the informal peanut-butter and snacks market are often marketed informally, whereas nuts from large-scale commercial areas destined for industrial use are marketed through the GMB. A study could include separate budgets for these different channels, to show the impact of marketing practices on farm incentives and incomes.

2.5 Selecting destinations and levels of processing

As noted earlier, PAM budgets must take all inputs and products all the way to and from national markets, in order to find national opportunity costs for each item. But there may exist several markets for each item, at various locations and levels of processing. With cotton, for example, one could make budgets for raw seed cotton going into the ginnery, or for cottonseed and cotton lint going out of the ginnery, or as cottonseed oil and cotton yarn after expressing and spinning.

For most agricultural products, the researcher should take the product to its simplest tradable form. Thus for cotton we would use the intermediate stage, measuring the costs of lint and seeds out of Cotton Marketing Board depots, since this is cotton's first exportable form. For grains, the level of processing is much less, since the GMB can trade bagged dry grain directly. For farm products which are rarely traded, such as millets

(mhunga and rapoko), we would take the product to GMB depot, where it becomes a substitute for more frequently traded grains.

3. Compiling the budget at market prices

Although this is not a paper on survey techniques or a review of the data available in Zimbabwe, the data requirements of the PAM are somewhat different from most research survey exercises and some explanation is in order.

3.1 Sources and uses of data

Most importantly, since the budgets include both on- and off-farm data, they must be compiled in stages. The on-farm costs generally account for most of the budget, are often the focus of attention, and generally deserve most of the research effort. In some contexts, they can be compiled primarily through reviews of existing survey results, cross-checked by comparison with aggregate data on yields and input sales, and validated by farmer interviews or data from other countries. For the present study, this is the approach being taken for the large-scale sector. For the communal sector, primary data is being collected through a formal, randomized farm survey, since existing data are too weak to be reliable.

It must be emphasized here that since the PAM is based on averages, its data requirements are much less stringent than methods requiring the estimation of marginal costs and benefits. This is because to get reliable estimates of marginal products, one must estimate a full production, profit or cost function, whereas to get reliable PAM budgets, one needs only a selection of points along that curve. Thus one needs fewer observations, over a smaller range around each point to be estimated. Sample sizes can be much smaller, and reliable data could even be obtained using rapid appraisal techniques such as group interviews.

Indeed, for the off-farm data on transport and processing which are a much smaller proportion of total costs, quick informal surveys are generally adequate. This is reinforced by the relatively smaller number of firms providing these services. In Zimbabwe, for example, most transport and primary processing data can be provided directly by the marketing boards.

3.2 Dividing nontradable, nonfactor inputs into components

Initial budgets will inevitably include a significant proportion of costs which are neither tradable goods, nor payments for factor services (capital and labour). This includes all transport and processing costs, plus tractor services, electricity, irrigation water, insurance, and so forth. These items, however, can be broken down into their component costs: tradable goods, capital, and labour. Alternatively, such costs

could be carried along in a fourth column of "nontradable inputs," but then the effects of macroeconomic conditions on these costs will not be reflected in the analysis. For completeness, therefore, it is desirable to break down nontradable, nonfactor inputs into their tradable, capital, and labour components.

This being said, it is clearly the level of such costs and not their breakdown which is most important. Indeed, for items which are only a few percent of total costs, a robust choice is simply to assign one-third shares to each cost category. This is very unlikely to be move the final product budgets more than a few tenths of a percent off the mark. For items which are a larger proportion of total costs, however, small informal surveys are justified. The cost of transport between farm and depot, for example, is generally around 10% of total costs in communal area production. It is therefore reasonably important to get an accurate breakdown, through a survey of transporters asking what proportion of their costs are labour, what proportion are capital services, and what proportion are tradable inputs. It may also be important to do the same for local equipment manufacturers, and to consult the published statements of accounts for electricity and railroads to break down their costs.

In some cases, it may be necessary to provide an estimate of the annual cost of an investment. While the simplest approach is simply to use the annual interest on the amount invested, this assumes that the asset does not depreciate -- that its salvage value is the same every year, so it has a very long useful life. In fact, depreciation should be considered, and although it is difficult to estimate depreciation directly, a relatively easy and yet realistic way to include it is through the capital recovery factor (CRF) approach. The capital recovery factor is defined as the proportion of an asset's net initial cost (purchase prise minus discounted salvage value) which must be recovered every year of the asset's life, in order to repay the investment at a given real interest rate.[23]

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[23]. The specific formula for the capital recovery factor (CRF) is:

$$CRF = [(1+i)^n * 1]/[(1+i)^n - 1],$$

where i is the annual opportunity cost of capital from the farmer's point of view, and n is the number of years that the investment is expected to last. In addition, the discounted net present value (NPV) of any salvage (s) would be:

$$NPV(s) = s/(1+i)^n.$$

Thus, the annual capital cost (ACC) of an investment (I) is:

The CRF is always somewhat larger than the simple interest on that investment, since the useful life of the asset is limited. For example, at 10% interest, an asset such as a tobacco barn with a useful life of 30 years must return about 11% each year on the initial investment -- while an asset with a useful life of ten years must return about 16% each year. Obviously, an asset with a life of only one year (such as fertilizers), must return 110% of its cost by the end of that year.

This approach can be used to separate out the annual value of capital invested in an activity, from the value of the labour used. For example, we might know from survey data that the contract cost of ploughing a hectare of communal area land is about $60. But how much of this is return on capital, and how much is labour costs? Our survey might also suggest that the average capital value of an ordinary team is about $600, with an average salvage value of, for example, half that at the end of four years. Ignoring the value of manure and any veterinary costs, at 10% interest, the annual capital value of the team is $100. Assuming the team is used to plough five hectares at the start of the season, then the capital value per hectare is $25. A similar analysis for the plough, yoke and chain yields about $3 annual capital cost per hectare. This leaves about $32 for labour; calculating about 1000 hours work per draft team including all the herding, this would yield returns to labour of about $0,15 per hour. This, however, mostly reflects returns to the very unskilled work of herding. Returns to peak-season or skilled labour such as actually ploughing or training animals would be higher.

To conclude, it is clear that the market-price budgets assembled for the PAM will not be perfect models of "average" farms. That is not possible; the available data would not permit it, even if there were such a thing as an "average" farm. But while our estimates are obviously not precise, they do provide considerable insight into the costs and profitability of each activity, and most importantly, allow direct comparisons with estimates of opportunity costs.

$$ACC(I) = [I-NPV(s)] * CRF.$$

To find the cost per hectare in each crop, this would then have to be multiplied by the items' per-hectare share of total annual use:

$$ACC(I)/ha = ACC(I)*(\text{use per hectare}/\text{total use})$$

For example, if a tractor is used 1,000 hours per year, of which 50 hours are devoted to each hectare of maize, the per-hectare share of annual use would be 50/1000 = 0.05 or 5%.

4. Estimating national opportunity costs and divergences

So far in compiling the PAM, we have made physical input-output budgets for each product, and found market prices for all items. Each physical budget represents a technique of production, and the totality of all budgets represents the full range of technology currently in use. When combined with market prices, these give current incentives and income levels in each activity (the first row of the PAM). All of this is directly observable in the economy, although it may be difficult to measure.

To complete the matrix, we must estimate either the national opportunity cost of each item (the second row), or the extent of divergences between market price and opportunity cost (the third row). These are, by definition, hidden from observation, and must be estimated using the analyst's best judgment. One approach would be consider each budget item individually, by adding up all known taxes, subsidies and effects of rationing and market failures to make a direct estimate of total divergences, or by finding the value of the item in its next best use to estimate opportunity costs. But this would be very difficult, and would not take advantage of the principal innovative feature of the PAM approach, which is to break down all items into their macroeconomic components. This allows all items in each category to be treated similarly, saving a great deal of effort, and giving clearer insight into the relationship between macroeconomic conditions and incomes in particular activities

We will begin with tradables, which is generally the largest category and often the one with the largest divergences.

4.1 The opportunity cost of tradables

Tradable products and inputs are, by definition, items which can be traded internationally. This provides an alternative to domestic production or consumption, which might allow the country to increase its total national income. The item's value in trade, or border price, would therefore be its opportunity cost from the nation's point of view if trade could increase national income. If trade could not increase national income, then the good is considered temporarily nontradable and its current opportunity cost would be its opportunity-cost value in domestic consumption.

This definition holds no matter what proportion of the good's production is or might be actually traded, as long as the measured border price is truly a marginal value at which additional trades could take place. If only a limited amount of trade could occur at that price, then this quantity would have to be noted as an opportunity for limited (usually regional) trade,

and another price at which further trades would occur should be calculated as well.

In addition, this definition holds whether or not the border price is a "free-market" price. Indeed, all border prices contain substantial transfers to and from other countries, but these are the other countries' problems. From Zimbabwe's point of view, border prices should be calculated as the values paid or received for a trade, no matter who receives or pays that value.

In the discussion below, how trade values can be estimated is discussed in some detail. This is obviously extremely important for PAM analysis, since it provides most of the opportunity cost information used to calculate national profits and divergences. The discussion applies to both outputs and inputs, although obviously the exact valuation of each output is more important than of each input, since each tradable input usually accounts for only a small fraction of total costs.

4.1.1 The foreign-currency cif/fob band. Each product has two values in trade: one price which would have to be paid for importing it, and a lower one which would be received for exporting it. Both of these "border" prices are initially formed entirely in foreign currency.

A good's import value is the price at which it could be bought from elsewhere (typically some large international "reference" market at a major port, such as Rotterdam), plus all insurance and freight charges from there to the domestic wholesale market. This is known as the "cif" (cost, insurance, freight) price of the item. The export value is the same foreign-market reference price, minus all the insurance and freight costs from the domestic to the foreign market. This is known as the "fob" ("free-on-board") price, that is the price at which the seller offers the good, ready for shipping to any destination. In landlocked countries like Zimbabwe, this is sometimes called an "for" ("free-on-rail") price.

These two values form a cif/fob "band" around the reference price, whose width is twice the transport costs. But since the reference price is determined by the interaction of the export supplies and import demands of many other countries, precisely which reference location is chosen is not very important: the prices for a specific commodity in all major ports move together, being separated only by the transport costs between ports. For example, when Argentina ships wheat to Angola, this never passes through Rotterdam, but using the Rotterdam price plus transport to Luanda will still reflect the opportunity cost to Angola of importing Argentine wheat.

What is crucial in measuring reference prices, however, is to specify the type and quality of the commodity correctly (since

different grades will have different prices), and to measure transport costs accurately. Good data on both reference prices and transport costs can be obtained from the agencies involved, either the government marketing boards or private traders. If data on actual trades in the region are unavailable, average prices for standard grades of major products are published in the FAO Monthly Bulletin of Statistics, the IMF International Financial Statistics, and in several other sources. If the country would trade items of a different quality than those for which prices were published, however, the use of published data may be misleading.

The cif/fob band for any commodity, of course, is not fixed. It shifts constantly as reference prices change, in response to shifting supply and demand in foreign countries. A major source of supply and demand changes is changing policy in the major trading countries. Recently, for example, grain prices have risen sharply as U.S. production cuts interact with large Eastern European and Asian imports. If anything is known about the direction and magnitude of future supply/demand changes, then these can be used to predict expected future prices. A reasonably good survey of market conditions for standard grades of basic items is published biannually by the World Bank, titled Price Prospects for the Major Primary Commodities, while studies of individual markets are produced by numerous other agencies. It is very difficult, however, to improve on current prices as an indicator of expected future prices, since even the direction of future changes is usually unpredictable.

In addition to shifting up or down, the cif/fob band will become wider or narrower as transport costs change. For most countries, this consists mostly of ocean shipping costs, which are relatively constant over time. Zimbabwe, however, is extremely vulnerable to conditions on the regional road, rail and port network, where marginal costs are currently being lowered by major infrastructural investments -- but where the possibility of devastating military attacks from South Africa remains all too significant.

4.1.2 The opportunity cost of foreign exchange. As noted above, each commodity's cif/fob band is initially fixed in foreign currency. In terms of domestic currency, the band therefore shifts up or down as the exchange rate changes. A depreciation of the domestic currency raises both cif and fob prices, making the production of both exportable and import-substituting goods more profitable. Appreciation, in contrast, pushes the band down, making the production of all tradables less profitable. To find the domestic-currency opportunity cost of each tradable, its cif and/or fob price must be divided by the opportunity cost of foreign exchange. Measuring the opportunity cost of foreign exchange can be approached in several different ways, but the method which is probably best suited to Zimbabwe is the real

exchange rate (RER) approach.[24] This method uses an index of domestic-currency prices of tradables (Pt), over domestic-currency prices of nontradable (Pnt), to show the average "price" or exchange ratio between these two types of commodities. This is a "real" exchange rate in the sense that it represents the price (or exchange ratio) between two types of goods in the real economy. In contrast, the exchange rate as published in the newspapers is a "nominal" exchange rate, since it represents a price between two types of money, whose value in terms of real goods may be constantly changing.

An RER index is rarely constant over time, since changes in resource scarcity and/or productivity will eventually change the relative values of tradable and nontradable goods, and hence the opportunity cost of foreign exchange. But such changes will occur only very slowly, in the long term. Much faster, short-term changes in an RER index occur because of changes in the money prices of different goods, which do not reflect the demand and supply of foreign exchange and therefore cause shortages of foreign exchange or other trade imbalances. The RER approach consists of separating out these short-term movements in money prices from the long-term equilibrium RER, so that the true long-run value of producing tradables instead of nontradables can be determined.

In Zimbabwe, an RER index can be built using CSO data on unit values of imports and exports (for Pt), and prices for bulky

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[24]. One alternative is the "elasticities" approach, which uses estimates of supply and demand elasticities for imports and exports to project the exchange rate at which the supply and demand for foreign exchange would be in balance. This involves building a model of the foreign exchange market, which is obviously extremely difficult to implement. Even if agreement on the structure of such a model could be reached, the required elasticities would be very difficult to estimate.

Another alternative is the "purchasing power parity" (PPP) approach, which uses indeces of domestic and foreign prices for a common basket of goods (usually, just the domestic and foreign consumer price indeces) to project the exchange rate at which domestic and foreign currency would have equal purchasing power. This is in fact quite similar to the RER approach. It consists of comparing the values of the same basket of goods in two types of currency, while the RER method compares two different baskets of goods in the same currency. Both methods monitor the same issues, but since the PPP approach includes more intermediate adjustment steps and generally uses indeces of larger aggregates, it is less sensitive to short-term or small changes than an RER index. Since the data necessary for the RER approach are available for Zimbabwe, it seems preferable to use them.

items such as bricks and timber from the building materials price index (for Pnt). Such an index has been falling fairly steadily since the mid-1970s, showing that the prices of nontradables have been rising faster than the prices of tradables. This is not because nontradable goods (mostly consisting of labour and other domestic resources) have become very much more scarce, or more productive, during this time; instead, it is because domestic prices have risen faster than overseas prices when converted at the nominal exchange rate.

Such an appreciation of the RER (or "real appreciation") occurs because the prices of nontradables are determined in Zimbabwe dollars, whereas the prices of tradables are determined in foreign currency (times the nominal exchange rate). Thus nontradables' prices reflect domestic inflation (subject to price controls, but controls can only delay inflation, not stop it); while tradables' prices reflect overseas inflation, times the rate of depreciation of the nominal exchange rate. Thus, the combination of domestic monetary and fiscal policy (affecting the price of nontradables, through the rate of inflation), and external trade and capital-flows policy (affecting the prices of tradables, though the nominal exchange rate), have caused tradables to appear increasingly cheap -- but this situation does not reflect the true supply and demand for tradables, as the serious current shortage of foreign exchange makes clear.

To restore the value of tradables to their long-term opportunity cost in terms of nontradables, their domestic-currency prices must be divided by the RER index value which reflects the degree of short-term policy-induced appreciation, after its long-term equilibrium value has been set to one. The precise level of this "true" RER involves subjective judgments, but it seems clear that in Zimbabwe, most realistic RER indeces are now somewhere around 20-40% below their long-run equilibrium values, so that the opportunity costs of tradables are between one-fourth and two-thirds above their current prices.[25]

To summarize, the domestic-currency cif/fob band for each commodity is composed of three elements, each of which must be carefully estimated: the expected reference price for the item to be traded (which fixes the position of the band), its expected

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[25]. With the long-run equilibrium level for an RER index set at 1.0, a real appreciation lowering the RER index by 20% (to 0.8) implies that the prices of tradables would have to be raised by one-fourth or 25% (1.25 = 1.0/0.8) to reach their opportunity costs in terms of nontradables. Similarly, a drop in the RER index of 40% (to 0.6) implies that the prices of tradables would have to rise by two-thirds or 67% (1.67 = 1.0/0.6) to reach their opportunity costs.

transport cost (which fixes the width of the band), and the opportunity cost of foreign exchange (which converts the foreign-currency band into domestic currency).

In addition to the foreign-currency cif/fob band at which very large trades, in either direction, could occur, there may be opportunities for limited trade at better prices. In Zimbabwe this is currently important for maize exports, since Zimbabwe's neighbors are net importers, whose opportunity costs are their cif prices. For a limited quantity of exports to these neighbors, Zimbabwe can therefore earn their cif prices minus the relatively small transport cost from Zimbabwe, rather than the region's much lower fob price. This price differential is currently reinforced by the foreign aid now available to assist SADCC-region trade.

Finally, for tradable inputs which form a small share of crop budgets, estimating border prices may not be worthwhile. It may be preferable to simply add or subtract domestic subsidies or taxes, and then multiply this by the opportunity cost of foreign exchange. This omits any market failures, but these would have a negligible impact on the final results where inputs are a small share of total costs.

4.1.3 Is a good importable, exportable, or neither? Whether a good's opportunity cost in trade should be at the top, bottom, or within the band depends on the position of the band, relative to the domestic opportunity cost of the good. If the opportunity cost of domestic production is below the bottom of the band (less than the fob price), then the good is "exportable" and the national opportunity cost should be the fob price. In this case, exporting increases national income, as the proceeds from exports can be used to buy goods with a higher value.

In contrast, if the opportunity costs of domestic production are above the band (higher than the cif price), then the good is "importable" and the national opportunity cost would be the cif price. In this case, importing increases national income, as it allows scarce domestic resources to be used in the production of other goods with a higher total value. And finally, if the good's opportunity cost of domestic production falls within the band, then the good is currently neither importable nor exportable. In this case, national opportunity cost would be the good's opportunity cost in domestic production. Because Zimbabwe faces relatively large transport costs, an unusually large proportion of its products are currently nontradable. This is in marked contrast with coastal countries in Asia, for example, where transport costs are low and cif/fob bands are very narrow, so that almost everything is tradable.

In any case, much of the analysis hinges on the estimation of the domestic opportunity cost of each product. One possible approach

might be to take input costs from the PAM budgets, but this would ignore the influence of demand on the product's value. In order to include demand effects, it is generally preferable to begin with the current domestic market price, and then modify that by an estimate of current divergences. These would include at least all observable government taxes and subsidies on the product, such as marketing board profits or losses, parastatal subsidies and excise taxes. They might also include an allowance for the effects of rationing and known market failures, but these are very difficult to estimate, and so must usually be omitted. And finally, the resulting net revenues should be valued at the opportunity cost of foreign exchange, since this allows domestic values to be directly compared with border prices.

For many items, the domestic opportunity cost will be well above or below the domestic-currency cif/fob band, so that the tradability status of the item is clear. In such cases, the item's national opportunity cost is its value in trade, and the calculated divergence is usually greater than that which could be estimated from observable taxes and subsidies. The other sources of divergence are not necessarily known -- they could include a wide range of policies and market failures. It is only where the estimated domestic opportunity cost is within the cif/fob band that it itself is used as the national opportunity cost of the item, as discussed in section 4.1.4 below.

One additional complication is that the domestic opportunity costs of the item will vary with the quantity consumed, where domestic demand equals domestic supply. The various PAM budgets for each crop will give a range of costs of production, and can be arranged from lowest to highest cost to give a rough upward-sloping step-wise supply curve, with costs increasing as systems with more remote locations and lower-productivity resources are employed. The equilibrium opportunity cost is incurred at the level of production where this upward-sloping supply curve meets the downward-sloping demand curve.

The equilibrium point may be above or below the current level of production; but in the absence of any information about the demand curve, and/or for the purpose of analysing small changes from the current situation, it is reasonable initially to take current demand levels as given, so that the equilibrium opportunity cost of domestic production is simply its current opportunity cost. Any additional information about demand conditions can then be considered separately, as discussed in section 6.3 below.

4.1.4 What if the item is neither importable nor exportable?
When a commodity is clearly importable or exportable, its opportunity cost is its value in trade, so that divergences are the differences between trade values and revenues at market prices. Such calculated divergences may include either the

effects of policy, market failures, or both. Some effects of policy will already be known, from the analyst's adding-up of observable taxes and subsidies. But the remainder of the divergence remains unexplained, and a very careful study of marketing arrangements would usually be needed to identify its sources.

In contrast, when the analyst judges a commodity to be currently neither importable nor exportable, a direct estimate of its domestic opportunity cost must be used in the PAM. As noted above this direct estimate is generally revenues at market prices, minus observable subsidies (or plus taxes). In this situation, the PAM approach fails to include the effects of market failures in its analysis -- but this is the only such case. Another important difference between this and other cases is that temporarily nontradable commodities should not be valued at the opportunity cost of foreign exchange, like other products. It should temporarily be considered, like labour and capital, to be a nontradable in terms of which the values of tradables are expressed.

4.2 The opportunity cost of capital

Ideally, our estimate of the opportunity cost of capital should be its highest available marginal value anywhere in the economy. But estimating this is extremely difficult. Since capital captures rents and is a major bearer of risk, the returns to capital in different activities vary widely, and its economy-wide marginal value is very difficult to measure.

In general, most economists have avoided making country-specific empirical estimates of the marginal value of capital, and prefer to use standard rates for various countries at similar per-capita incomes and savings rates. These range between 4-5% for the most capital-rich countries, and 15-20% for the most capital-poor countries. Zimbabwe is generally considered to be somewhere in the middle, at around 8-10%.

A real rate of 8-10% is appropriate for two reasons. Firstly, this is roughly the average rate of return on domestic capital markets, where a relatively low level of per-capita income is balanced by relatively high level of current and historical savings. Secondly, this is roughly the cost of foreign borrowing, which is used by government to supplement the domestic capital market.

For farm-level credit, we should probably use the upper end of this range, since rural loans are both riskier and more costly to administer than credit to urban industries. But even the approximate figure implies that AFC credit contains a considerable subsidy, since their all-in nominal rate for short-term loans of 13.9% is very close to the rate of inflation, resulting in a real rate of about zero.

4.3 The opportunity cost of labour

Like capital, labour's opportunity cost should reflect its marginal contribution anywhere in the economy. But in the Zimbabwean context, agriculture in communal areas is the dominant residual employer; it is what people do when they cannot find jobs elsewhere. Thus, the marginal product of unskilled labour in small-scale farming can be taken as its opportunity cost.

To estimate labour's marginal product directly would require the estimation of a farm production function, using data from a wide range of farms throughout the country. Since the data required for this remain unavailable, average products in various activities will have to be used instead. If the activities concerned have reasonably constant marginal returns, however, these will not be very different from average returns.

Preliminary results of survey work suggest that unskilled and off-peak labour generally yields on the order of $0,15-$0,20 per hour, while more skilled and peak labour yields at least twice that. This is between one-third and two-thirds of the agricultural minimum wage, which is consistent with the estimates used elsewhere for project planning purposes.

5. Limitations and extensions of the PAM

To conclude this brief review of the methodology behind the Policy Analysis Matrix, it seems appropriate to discuss just how far it would be appropriate to carry these methods. Given that the PAM is being used to approach an appropriate set of hypotheses as discussed in section 2 above, how much can the PAM reveal, and what other techniques might be used in combination with the PAM to extend its reach?

5.1 The assumptions behind the PAM

The PAM is clearly an unusually simplified method of economic analysis. It requires a minimum of data, and organizes it into a framework of accounting identities. The PAM is therefore not an economic theory or a model of the economy, since it contains no behavioural equations; it is much more similar to a biologist's microscope than to most economists' models. Nevertheless, the definition of terms in the PAM is derived from numerous models of welfare economics and international trade, so that although using the PAM does not necessarily imply acceptance of the assumptions behind these models, some familiarity with them will assist the user to interpret PAM results.

Two elements of many models are particularly important. Firstly, there is the concept of resource mobility, which underlies the idea of opportunity cost. The opportunity cost of a product or resource must reflect the minimum value at which it would be

attracted to a given activity. If the product or resource does not respond to value, then it would in fact be a completely immobile fixed factor, with a claim on profits instead of an opportunity cost. For example, if a PAM study uses opportunity costs of 10% for capital and $0,30 per hour for labour, and yet these resources would not, in fact, be available to the given activities at these returns, then the activities' estimated national profits will be artificially high. Similarly, if these resources could be attracted at lower returns, then the estimated national profits will be artificially low. It is clearly the mobility of resources within the economy which gives "opportunity cost" its meaning. If an analyst does not believe that a resource is mobile, he or she should not give it an opportunity cost.

Secondly, there is the concept of national income itself, in terms of which national profits and opportunity costs are defined. This involves adding up all the income earned by everyone, without regard to who earns it. Obviously, the sense of justice in such a concept is very limited, and national income therefore cannot be a prescriptive tool for policy. It can only be a diagnostic tool, to measure income flows. Actual policy-making inevitably includes the policy-makers' preferences as to who should receive income transfers, and who should pay for them. But policies do not always do what policy-makers claim (or hope) they will do; often, policies enacted in the name of the poor actual benefit the rich. This may occur out of cynicism, or by mistake -- but the analytical power of the PAM lies in uncovering the actual transfer effects of policies, so that these may be brought more closely in line with the genuine objectives of government.[26]

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[26]. If the massive income transfers out of tradable products and into nontradable activities which characterized many developing countries in the 1960s, '70s and early '80s had been diagnosed earlier, they might have been reversed earlier, before the terrible adjustment crises of the mid-1980s. In the event, the heavy implicit taxation of agriculture did not become well-understood until such books as Michael Lipton's Why Poor People Stay Poor: Urban Bias in World Development (Cambridge, MA: Harvard University Press, 1977) and T.W. Schultz, ed., Distortions of Agricultural Incentives (Bloomington, IN: Indiana University Press, 1978) became influential, and large-scale empirical research was done such as in Malcolm Bale and Ernst Lutz, "Price Distortions in Agriculture: An International Comparison" (American Journal of Agricultural Economics, vol. 63: 8-22).

5.2 Measurement and specification errors

Because the PAM generally relies on average costs and benefits, it usually provides a more robust approach than methods which use marginal costs and benefits. This is because averages are estimates at a single point, whereas marginal effects require estimates of a curve. Nevertheless, the point estimates used in the PAM approach are still subject to considerable measurement error.

Firstly, PAM budgets should indicate the performance of a "representative" plot in an each farming system. It might be all too easy to consider only relatively accessible, high-input/high-yield plots, or to believe the opinions of biased officials. Fieldwork, even through short-term, informal surveys, is important to get a diversity of points of view, and to reduce any bias in the averages used.

In addition, if randomized survey data are available, then the importance of non-systematic error can be assessed, using the variances of yields and other important variables to perform tests of statistical significance on the results. If yield variances are large enough, even very large differences in average national profits or average domestic resource costs can be statistically insignifant.[27] If necessary, variance estimates can even be borrowed from other surveys, and applied to the PAM results to test their statistical significance.

If a PAM study covers a large enough area, careful checks of budget data against aggregate figures can be made. For example, if the budgets suggest that aggregate use of one type of fertilizer is twice (or half) what the fertilizer companies claim they sell in that area, it's usually more likely that the budgets are wrong than that the fertilizer companies are lying. Similar checks can be done on other inputs, and on yield estimates using aggregate area and production figures.

Secondly, PAM budgets should indicate performance in an "average" year. This is most important for revenues, since crop yields depend crucially on weather conditions. Early-season inputs are much more stable, since most farmers start by expecting a roughly average year, but mid- and end-season inputs will vary with the weather and crop performance. Some time-series data should be available to suggest average recent yield levels, and it might even be possible to use multiple regression to separate out the effects of price and input use changes from weather variability.

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[27]. This point is shown clearly with empirical evidence in John McIntire and Chris Delgado, "Statistical Significance of Indicators of Efficiency and Incentives: Examples from West African Agriculture," American Journal of Agricultural Economics, November 1985: 733-38.

But inevitably, a good deal of judgment will have to be exercised as to whether survey results were obtained under average weather conditions, and if not, what degree of correction should be applied to obtain more typical results. In addition, tests of statistical significance could again be performed to judge the degree of non-systematic error, using variances from time-series data. Similar issues are discussed in section 5.5 below, addressing the impact of differential risk on the interpretation of PAM results.

Another type of error arises from mis-specification of the crop budget, through omitting items or not valuing them correctly. Analysts could easily forget items such as the capital costs of kraals, fencing, and storage buildings, the time required to sort and bag grains, or the revenue from cattle manure and crop residues. In general such items are small and will have little effect on profitability -- especially on relative profitabilities, if the same mistakes have been made on all budgets -- but the analyst should nevertheless be aware of the need for budgeting to be as complete as possible.

5.3 Demand factors

As was discussed in section 5.1.3, domestic demand has a great influence over domestic opportunity costs. This influence can be of two sorts. Firstly, if the quantity supplied changes, then the price elasticity of demand will determine how much prices (or opportunity costs) will change. This may be of great importance for a study considering significant changes in the quantity of a product being produced or traded. For goods with relatively inelastic demand, such as most staples, a change in quantity will result in a more than proportional change in price. A reduction in quantity will cause an increase in total consumer expenditure on the good, and vice-versa. Some data on demand elasticity should therefore be included in any study involving significant changes in the quantity supplied or traded of a major product.

A second demand-side influence occurs when the quantity demanded changes. This could occur through changing the level or distribution of consumer income, through changing processing costs, or through changing tastes. Increases in income (or shifts in income distribution towards the poor) will increase demand for higher-valued foods, such as meat and wheat products. Similarly, reductions in processing costs for grains or oilseeds will increase demand for them, by reducing their costs to the consumer. Cross-price effects from the affected product onto other items will also occur, but with a much smaller magnitude.

As long as the product is traded, such shifts in demand can be accomodated by changes in quantities imported or exported, so that domestic production, price and opportunity cost remain unaffected. It is only when increases in domestic demand bring exports of a good to zero, or when falling demand eliminates

imports, that the quantity produced domestically would be forced to respond. At that point, the price and opportunity cost of the item are likely to change, along the domestic supply curve.

In such situations, it would be necessary to use estimates of the elasticity of supply, or models of the whole supply curve, to predict the changes in domestic production which result from the shift in demand. These are best estimated econometrically, but if necessary, it is possible to build up a synthetic step-wise supply curve, using PAM budgets to show the costs in several distinct production systems for the crop. The current extent of each system is given simply by its current output, but to estimate each system's response to changing conditions the additional resources available to it at budgeted prices would have to be specified, and new activity levels would have to be found in the context of a simple mathematical programming model.

5.4 Dynamic factors

As has repeatedly been mentioned above, PAM data is meant to reflect current conditions. As such it offers a "snapshot" view of what is, inevitably, an ever-changing reality. Occasionally, however, one has sufficient historical data to build PAMs for past conditions, or enough predictions to build forward-looking PAMs. In these cases, a series of matrices can be built, showing the evolution of budgets as productivities and/or prices change over time. Changes can be shown either in the whole matrix, or in some variables only using a "partial budgeting" approach.

All data in the PAM, of course, are subject to change over time. But only a few items can be changed at once if meaningful comparisons are to be made. Significant studies could be made of, for example, changing technology (especially crop varieties and input use) through changes in the physical coefficients of PAM budgets; or of changing resource availabilities (especially the scarcity of labour and foreign exchange) through adjustments in macroeconomic prices.[28]

Occasionally, something may be known about changes in product prices, in which case their implications can be carefully studied. In their study of the effects of entry into the European Community on Portuguese agriculture, for example, Scott Pearson and his colleagues knew that product prices would be switching to levels determined by the EC's Common Agricultural Policy (CAP). These are relatively predictable, and were included in forward-looking PAMs.

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[28]. One example of such a study is Laurian Unnevehr, "Changing Comparative Advantage in Philippine Rice Production: 1966 to 1982," Food Research Institute Studies, vol. 20, no. 1 (1986): 43-71.

In some situations, one might wish to investigate the effects on profits and incomes of public investment in crop research or infrastructure, by simulating the impact of those investments on technology or prices. For example, one might ask what the effect of a 10% increase in average yields would be, or a 10% reduction in transport costs, since this would help to suggest the magnitude of the returns from the investment needed to reach these targets.

5.5 Risk factors

The PAM is designed to indicate profits in an average year. But every farmer knows that about half of all years are below average, and takes steps to minimize his or her losses in particularly bad years. Much of farmers' own risk-avoidance behaviour is included in PAM results, since cropping patterns and early-season input use reflect farmers' perceptions of risk as well as of relative profitabilities. The interpretation of PAM results for policy purposes, however, should also include some consideration of this issue.

If all activities have the same degree of risk, then there is little reason to include risk in the analysis. But where there are significant differences, then there is every reason to do so. In Zimbabwe, for example, research showing that irrigated maize production was on average 10% less socially profitable than rainfed maize would not be surprising. But if rainfed production has a coefficient of variation of 40%, while irrigated production varies by only 15%, then the extra cost of irrigation might be considered a bargain.

Unfortunately, the relative importance of risk is a very subjective matter. It is not possible to compare the riskiness of different activities objectively, since everyone has a different willingness to bear risk. But it is possible to measure risk, and to allow policy-makers to make their own subjective trade-offs between their desire to avoid risk and their other objectives.

To measure the variability in PAM indicators themselves, the analyst could calculate the variances of several key variables, such as yields and the border prices of outputs, and compute the resulting variance of PAM indicators using standard formulas.[29]

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[29]. These formulas can be found in any standard statistics text. They will typically include one or more co-variance terms, but most of these can safely be assumed to be insignificant. For regional trade, there would be a significant negative co-variance between national yields and regional prices (since a bad year for Zimbabwe is often bad elsewhere as well), but most regional food trades are actually made at concessional prices under bi- or tri-lateral aid agreements so the effect of this can probably be

The coefficients of variation of, for example, the DRCs for various activities could then be directly compared, along with each activity's average DRC. Alternatively, the probability of each activity's DRC falling below one can be calculated and compared, along with the average figure.

Another approach would be to calculate the variability of other parameters, and use these to compare the different activities. For example, one might compare the variance in annual marketings from alternative production systems, or, to compare different crops, one might compare the probabilities of total marketings falling below annual domestic consumption.

In addition, when considering risk issues it should not always be assumed that profitability indicators from the PAM have a symmetric probability distribution around the observed mean. It could be that the distribution is skewed, so that most years are actually above or below the mean. If a distribution is skewed below the mean, most years are slightly below average, while the smaller number of good years are very much above average. This would be the case, for example, of the world price of basic commodities, which tend to show wide valleys and narrow peaks over time. It is highly unlikely, however, that this phenomenon would be of greater significance in assessing the importance of risk than relative variances or the probabilities of a shortfall.

5.6 General-equilibrium factors

In the PAM approach all opportunity costs are estimates, made from available evidence under current supply/demand conditions. But if major changes in the supply or demand for one resource were to occur, the opportunity costs of other items would also change.[30] For example, consider the politically important issue of the effects of a devaluation on the opportunity costs of labour.

In its simplest, most direct effects, a devaluation, which raises the profits to be made from the production of tradable goods, attracts labour to these activities. At the same time, a devaluation reduces profits in the production of nontradables, and causes the demand for labour in these activities to shrink.

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ignored as well.

30. For this reason, the PAM's results are "partial-equilibrium" indicators. However, this term is also used for indicators such as NPCs and EPCs, or for incompletely-calculated DRCs and PSEs, which consider divergences in only a few markets. The PAM considers divergences in the markets for all budgeted items, leaving out only cross-price effects between budgeted items and with the markets for other goods.

As long as more workers are absorbed into the tradables sector than are retrenched from the nontradables sector, total employment (and hence the opportunity cost of labour) will rise.

In the Zimbabwean context, this is the most likely outcome, since the tradables sector (mostly self-employed farmers and small industries) is both larger and more labour-intensive than the nontradables sector (mostly services and large-scale industries). But in economies more dependent on nontradables, the opposite would be true and devaluations would tend to increase unemployment and lower the opportunity costs of labour.

General equilibrium effects such as these, however, are usually smaller in magnitude, slower in impact, and harder to predict than the partial-equilibrium effects which are the focus of the PAM approach. Relatively large models, linking several sectors of the economy, must usually be built to analyse them, and this is likely to remain the province of academic research.[31] Operational policy analysis, especially in data-poor countries, will no doubt continue to be done within a partial equilibrium framework. But if anything is known about general equilibrium effects, this information can easily be included in a PAM-based study, much as information about elasticities, dynamic factors, and risk can be used.

6. Conclusions: The PAM in its context

In summary, the PAM is a simple framework of accounting identities, designed to give a snapshot picture of current comparative advantage and income transfers in alternative activities. The matrix builds a link between microeconomic, sectoral, and macroeconomic data, to go beneath current market prices and see the sources of comparative advantage and transfers within the economy.

Where more data are available, it is possible to go well beyond this diagnosis, into the realm of modeling and prediction. But

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31. Good descriptions of several such models are given in Sherman Robinson, "Multisectoral Models of Developing Countries: A Survey" (Berkeley, CA: University of California, Giannini Foundation of Agricultural Economics, 1986), and the mathematics behind them is explained in Alan Manne, "On the Formulation and Solution of Economic Equilibrium Models," in A.S. Manne, ed., Economic Equilibrium: Model Formulation and Solution (Amsterdam: North Holland, 1985). The relation between the solutions of general equilibrium models and opportunity costs is discussed in Edward Tower and Gary Pursell, "On Shadow Pricing," World Bank Staff Working Paper No. 792 (Washington, DC: The World Bank, 1986).

for policy-makers who need rapid insight into current conditions, or for academics seeking methods applicable where data are limited, the PAM offers a clear, straightforward approach to a range of urgent practical issues.

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